CHAPTER 2

SITE AND CIVIL FACILITIES DESIGN

Section 1. SITE SELECTION

2-1. Introduction

Since the selection of a plant site has a significant influence on the design, construction and operating costs of a power plant, each potential plant site will be evaluated to determine which is the most economically feasible for the type of power plant being considered.

2-2. Environmental considerations

a. Rules and regulations. All power plant design, regardless of the type of power plant, must be in accordance with the rules and regulations which have been established by Federal, state and local governmental bodies.

b. Extraordinary design features. To meet various environmental regulations, it is often necessary to utilize design features that will greatly increase the cost of the power plant without increasing its efficiency. For example, the cost of the pollution control equipment that will be required for each site under consideration is one such item which must be carefully evaluated.

2-3. Water supply

a. General requirements. Water supply will be adequate to meet present and future plant requirements. The supply maybe available from a local municipal or privately owned system, or it may be necessary to utilize surface or subsurface sources.

b. Quality. Water quality and type of treatment required will be compatible with the type of power plant to be built.

c. Water rights. If water rights are required, it will be necessary to insure that an agreement for water rights provides sufficient quantity for present and future use.

d. Water wells. If the makeup to the closed system is from water wells, a study to determine water table information and well drawdown will be required. If this information is not available, test well studies must be made.

e. *Once-through system.* If the plant has a once through cooling system, the following will be determined:

(1) The limitations established by the appropriate regulatory bodies which must be met to obtain a permit required to discharge heated water to the source.

(2) Maximum allowable temperature rise permissible as compared to system design parameters. If system design temperature rise exceeds permissible rise, a supplemental cooling system (cooling tower or spray pond) must be incorporated into the design.

(3) Maximum allowable temperature for river or lake after mixing of cooling system effluent with source. If mixed temperature is higher than allowable temperature, a supplemental cooling system must be added. It is possible to meet the conditions of (2) above and not meet the conditions in this subparagraph.

(4) If extensive or repetitive dredging of waterway will be necessary for plant operations.

(5) The historical maximum and minimum water level and flow readings. Check to see that adequate water supply is available at minimum flow and if site will flood at high level.

2-4. Fuel supply

Site selection will take into consideration fuel storage and the ingress and egress of fuel delivery equipment.

2-5. Physical characteristics

Selection of the site will be based on the availability of usable land for the plant, including yard structures, fuel handling facilities, and any future expansion. Other considerations that will be taken into account in site selection are:

-Soil information.
-Site drainage.
- Wind data.
-Seismic zone.
-Ingress and egress.

For economic purposes and operational efficiency, the plant site will be located as close to the load center as environmental conditions permit.

2-6. Economics

Where the choice of several sites exists, the final selection will be based on economics and engineering studies.

Section II. CIVIL FACILITIES, BUILDINGS, SAFETY, AND SECURITY

2-7. Soils investigation

An analysis of existing soils conditions will be made to determine the proper type of foundation. Soils data will include elevation of each boring, water table level, description of soil strata including the group symbol based on the Unified Soil Classification System, and penetration data (blow count). The soils report will include recommendations as to type of foundations for various purposes; excavation, dewatering and fill procedures; and suitability of on-site material for fill and earthen dikes including data on soft and organic materials, rock and other pertinent information as applicable.

2-8. Site development

a. Grading and drainage.

(1) *Basic criteria.* Determination of final grading and drainage scheme for a new power plant will be based on a number of considerations including size of property in relationship to the size of plant facilities, desirable location on site, and plant access based on topography. If the power plant is part of an overall complex, the grading and drainage will be compatible and integrated with the rest of the complex. To minimize cut and fill, plant facilities will be located on high ground and storm water drainage will be directed away from the plant. Assuming on site soils are suitable, grading should be based on balanced cut and fill volume to avoid hauling of excess fill material to offsite disposal and replacement with expensive new material.

(2) *Drainage.* Storm water drainage will be evaluated based on rainfall intensities, runoff characteristics of soil, facilities for receiving storm water discharge, and local regulations. Storm water drains or systems will not be integrated with sanitary drains and other contaminated water drainage systems.

(3) *Erosion prevention.* All graded areas will be stabilized to control erosion by designing shallow slopes to the greatest extent possible and by means of soil stabilization such as seeding, sod, stone, riprap and retaining walls.

b. Roadways.

(1) *Basic roadway requirements.* Layout of plant roadways will be based on volume and type of traffic, speed, and traffic patterns. Type of traffic or vehicle functions for power plants can be categorized as follows:

-Passenger cars for plant personnel.
-Passenger cars for visitors.
-Trucks for maintenance material deliveries.
-Trucks for fuel supply.
-Trucks for removal of ash, sludge and other waste materials.

(2) *Roadway material and width.* Aside from temporary construction roads, the last two categories described above will govern most roadway design, particularly if the plant is coal fired. Roadway material and thickness will be based on economic evaluations of feasible alternatives. Vehicular parking for plant personnel and visitors will be located in areas that will not interfere with the safe operation of the plant. Turning radii will be adequate to handle all vehicle categories. Refer to TM 5-803-5/ NAVPAC P-960/AFM 88-43; TM 5-818-2/ AFM 88-6, Chap. 4; TM 5-822-2/AFM 88-7, Chap. 7; TM 5-822-4/AFM 88-7, Chap. 4; TM 5-822 -5/AFM 88-7, Chap. 3; TM 5-822-6/AFM 88-7, Chap. 1; TM 5-822-7/AFM 88-6, Chap. 8; and TM 5-822-8.

c. Railroads. If a railroad spur is selected to handle fuel supplies and material and equipment deliveries during construction or plant expansion, the design will be in accordance with American Railway Engineering Association standards. If coal is the fuel, spur layout will accommodate coal handling facilities including a storage track for empty cars. If liquid fuel is to be handled, unloading pumps and steam connections for tank car heaters may be required in frigid climates.

2-9. Buildings

a. Size and arrangement.

(1) *Steam plant.* Main building size and arrangement depend on the selected plant equipment and facilities including whether steam generators are indoor or outdoor type; coal bunker or silo arrangement; source of cooling water supply relative to the plant; the relationship of the switchyard to the plant; provisions for future expansion; and , aesthetic and environmental considerations. Generally, the main building will consist of a turbine bay with traveling crane; an auxiliary bay for feedwater heaters, pumps, and switchgear; a steam generator bay (or firing aisle for semi-outdoor units); and general spaces as may be required for machine shop, locker room, laboratory and office facilities. The general spaces will be located in an area that will not interfere with future plant expansion and isolated from main plant facilities to control noise. For very mild climates the turbine generator sets and steam generators may be outdoor type (in a weather protected, walk-in enclosure) although this arrangement presents special maintenance problems. If incorporated, the elevator will have access to the high-

est operating level of the steam generator (drum levels).

(2) *Diesel plant.* The requirements for a building housing a diesel generator plant are the same as for a steam turbine plant except that a steam generator bay is not required.

b. Architectural treatment.

(1) The architectural treatment will be developed to harmonize with the site conditions, both natural and manmade. Depending on location, the environmental compatibility y may be the determining factor. In other cases the climate or user preference, tempered with aesthetic and economic factors, will dictate architectural treatment. Climate is a controlling factor in whether or not a total or partial closure is selected. Semi-outdoor construction with the bulk of the steam generator not enclosed in a boiler room is an acceptable design.

(2) For special circumstances, such as areas where extended periods of very high humidity, frequently combined with desert conditions giving rise to heavy dust and sand blasting action, indoor construction with pressurized ventilation will be required not only for the main building but also, generally, for the switchyard. Gas enclosed switchyard installations may be considered for such circumstances in lieu of that required above.

(3) Control rooms, offices, locker rooms, and some out-buildings will be enclosed regardless of enclosure selected for main building. Circulating water pumps may be installed in the open, except in the most severe climates. For semi-outdoor or outdoor stations, enclosures for switchgear and motor controls for the auxiliary power system will be enclosed in manufacturer supplied walk-in metal housings or site fabricated closures.

c. Structural design.

(1) *Building framing and turbine pedestals.* Thermal stations will be designed utilizing conventional structural steel for the main power station building and support of boiler. The pedestal for supporting the turbine generator (and turbine driven boiler feed pump if utilized) will be of reinforced concrete. Reinforced concrete on masonry construction may be used for the building framing *(not* for boiler framing); special concrete inserts or other provision must be made in such event for support of piping, trays and conduits. An economic evaluation will be made of these alternatives.

(2) *Exterior walls.* The exterior walls of most thermal power stations are constructed of insulated metal panels. However, concrete blocks, bricks, or other material may be used depending on the aesthetics and economics of the design.

(3) *Interior walls.* Concrete masonry blocks will be used for interior walls; however, some specialized areas, such as for the control room enclosure and for offices, may utilize factory fabricated metal walls, fixed or moveable according to the application.

(4) *Roof decks.* Main building roof decks will be constructed of reinforced concrete or ribbed metal deck with built-up multi-ply roofing to provide waterproofing. Roofs will be sloped a minimum of 1/4,-inch per foot for drainage.

(5) *Floors.* Except where grating or checkered plate is required for access or ventilation, all floors will be designed for reinforced concrete with a nonslip finish.

(6) *Live loads.* Buildings, structures and all portions thereof will be designed and constructed to support all live and dead loads without exceeding the allowable stresses of the selected materials in the structural members and connections. Typical live loads for power plant floors are as follows:

(a) Turbine generator floor	500 psf
(b) Basement and operating floors except turbine generator floor	200 psf
(c) Mezzanine, deaerator, and miscellaneous operating floors	200 psf
(d) Offices, laboratories, instrument shops, and other lightly loaded areas	100 psf

Live loads for actual design will be carefully reviewed for any special conditions and actual loads applicable.

(7) *Other loads.* In addition to the live and dead loads, the following loadings will be provided for:

(a) Wind loading. Building will be designed to resist the horizontal wind pressure available for the site on all surfaces exposed to the wind.

(b) Seismic loading. Buildings and other structures will be designed to resist seismic loading in accordance with the zone in which the building is located.

(c) *Equipment loading.* Equipment loads are furnished by the various manufacturers of each equipment item. In addition to equipment dead loads, impact loads, short circuit forces for generators, and other pertinent special loads prescribed by the equipment function or requirements will be included.

d. Foundation design.

(1) Foundations will be designed to safely support all structures, considering type of foundation and allowable bearing pressures. The two most *common* types of foundations are spread footings and pile type foundations, although "raft" type of other special approaches may be utilized for unusual circumstances.

(2) Pile type foundations require reinforced concrete pile caps and a system of reinforced concrete beams to tie the caps together. Pile load capabilities may be developed either in friction or point

bearing. The allowable load on piles will be determined by an approved formula or by a load test. Piles can be timber, concrete, rolled structural steel shape, steel pipe, or steel pipe concrete filled.

(3) Design of the reinforced concrete turbine generator or diesel set foundation, both mat and pedestal, will be such that the foundation is isolated from the main building foundations and structures by expansion joint material placed around its perimeter. The design will also insure that the resonance of the foundation at operating speed is avoided in order to prevent cracking of the foundation and damage to machines caused by resonant vibration. The foundation will be designed on the basis of deflection. The limits of deflection will be selected to avoid values of natural frequency by at least 30 percent above or 30 percent below operating speed.

(4) Vibration mounts or "floating floor" foundations where equipment or equipment foundation inertia blocks are separated from the main building floor by springs or precompressed material will generally not be used in power plants except for ventilation fans and other building service equipment. In these circumstances where such inertia blocks are considered necessary for equipment not normally so mounted, written justification will be included in the project design analysis supporting such a necessity.

(5) The location of turbine generators, diesel engine sets, boiler feed pumps, draft fans, compressors, and other high speed rotating equipment on elevated floors will be avoided because of the difficulty or impossibility of isolating equipment foundations from the building structure.

2-10. Safety.

a. Introduction. The safety features described in the following paragraphs will be incorporated into the power plant design to assist in maintaining a high level of personnel safety.

b. Design safety features. In designing a power plant, the following general recommendations on safety will be given attention:

(1) Equipment will be arranged with adequate access space for operation and for maintenance. Wherever possible, auxiliary equipment will be arranged for maintenance handling by the main turbine room crane. Where this is not feasible, monorails, wheeled trucks, or portable A-frames should be provided if disassembly of heavy pieces is required for maintenance.

(2) Safety guards will be provided on moving parts of all equipment.

(3) All valves, specialties, and devices needing manipulation by operators will be accessible without ladders, and preferably without using chain wheels. This can be achieved by careful piping design, but some access platforms or remote mechanical operators may be necessary.

(4) Impact type handwheels will be used for high pressure valves and all large valves.

(5) Valve centers will be mounted approximately 7 feet above floors and platforms so that rising stems and bottom rims of handwheels will not be a hazard.

(6) Stairs with conventional riser-tread proportions will be used. Vertical ladders, installed only as a last resort, must have a safety cage if required by the Occupational Safety and Health Act (OSHA).

(7) All floors, gratings and checkered plates will have non-slip surfaces.

(8) No platform or walkway will be less than 3 feet wide.

(9) Toe plates, fitted closely to the edge of all floor openings, platforms and stairways, will be provided in all cases.

(10) Adequate piping and equipment drains to waste will be provided.

(11) All floors subject to washdown or leaks will be sloped to floor drains.

(12) All areas subject to lube oil or chemical spills will be provided with curbs and drains,

(13) If plant is of semi-outdoor or outdoor construction in a climate subject to freezing weather, weather protection will be provided for critical operating and maintenance areas such as the firing aisle, boiler steam drum ends and soot blower locations.

(14) Adequate illumination will be provided throughout the plant. Illumination will comply with requirements of the Illuminating Engineers Society (IES) Lighting Handbook, as implemented by DOD 4270.1-M.

(15) Comfort air conditioning will be provided throughout control rooms, laboratories, offices and similar spaces where operating and maintenance personnel spend considerable time.

(16) Mechanical supply and exhaust ventilation will be provided for all of the power plant equipment areas to alleviate operator fatigue and prevent accumulation of fumes and dust. Supply will be ducted to direct air to the lowest level of the power plant and to areas with large heat release such as the turbine or engine room and the boiler feed pump area. Evaporative cooling will be considered in low humidity areas. Ventilation air will be filtered and heated in the winter also, system air flow capacity should be capable of being reduced in the winter. Battery room will have separate exhaust fans to remove hydrogen emitted by batteries as covered in TM 5-811-2/AFM 88-9, Chap. 2.

(17) Noise level will be reduced to at least the

recommended maximum levels of OSHA. Use of fan silencers, compressor silencers, mufflers on internal combustion engines, and acoustical material is required as discussed in TM 5-805-4/AFM 88-37/NAVFAC DM-3.1O and TM 5-805-9/AFM 88-20/NAVFAC DM-3.14. Consideration should be given to locating forced draft fans in acoustically treated fan rooms since they are usually the largest noise source in a power plant. Control valves will be designed to limit noise emissions.

(18) A central vacuum cleaning system should be considered to permit easy maintenance of plant.

(19) Color schemes will be psychologically restful except where danger must be highlighted with special bright primary colors.

(20) Each equipment item will be clearly labelled in block letters identifying it both by equip ment item number and name. A complete, coordinated system of pipe markers will be used for identification of each separate cycle and power plant service system. All switches, controls, and devices on all control panels will be labelled using the identical names shown on equipment or remote devices being controlled.